Chemical Vapor Infiltration of TiN Into a cBN Matrix For a Composite cBN-TiN Coating: Advanced Materials and Processes

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Diamond is the hardest known material, and consequently, is the hardest material used in the cutting tool industry. However, since carbon is soluble in iron, diamond does not hold up well in applications involving ferrous materials where relatively high cutting temperatures are generated. Cubic boron nitride (cBN), known as the second hardest material, has good thermal stability and chemical inertness with respect to ferrous materials. Currently, cBN is being used in bulk form as tool insert bodies or as brazed segments in combination with tool bodies, usually WC-Co. A number of technical groups around the world are also working on the development of a cBN coating in much the same way as diamond coatings have been developed for cutting tools in recent years. Such coatings on cemented carbide substrates would provide the hardness and chemical resistance of cBN in combination with the toughness of a cemented carbide body.

Most groups working on cBN film deposition employ either a high energy plasma or ion bombardment to create stabilization of the cubic phase relative to the hexagonal or amorphous phases that are more thermodynamically stable, but do not have the hardness of cBN. These methods, although they result in the formation of very thin films (<1μm) of cBN, have, so far, not demonstrated the capability to form cBN independent of the other phases. Invariably, amorphous and/or hexagonal phase BN forms on the substrate before the cBN phase can be stabilized. Another problem is the high intrinsic compressive stresses in the cBN films when they are formed using these methods. These stresses can overwhelm the adhesive bonds between the coating and the substrate leading to delamination. This problem severely limits the functional thickness of these films.

An alternative method for depositing a composite cBN-TiN film has been developed for wear-related applications. The coating is deposited in a two-stage process utilizing ESC (electrostatic spray coating) and CVI (chemical vapor infiltration). ECS of cBN powder forms a porous particulate coating on the substrate. CVI is a derivative of conventional chemical vapor deposition (CVD) processes. The deposition of titanium nitride (TiN) is controlled in CVI in such a way that the TiN coating grows uniformly on the individual cBN particles and substrate throughout the depth of the ESC layer. This can be done by manipulating CVD parameters for the deposition of TiN so that the rates of diffusion of the reactants, $TiCl_4$, H_2 and N_2, are faster than the rate of growth of the TiN layer. In other words, the reactant diffusion rate must be faster than the rate of formation of the products, TiN and HCl. This can be accomplished by slowing down the CVI reaction. Fully dense films of cBN particles evenly dispersed in a continuous TiN matrix have been developed. Testing in metal cutting has shown an increase in tool life (turning – 4340 steel) of three to seven times, depending on machining parameters, in comparison with CVD deposited TiN films. **CVI of TiN in a porous cBN matrix to develop advanced composite coatings is the primary focus of this presentation and proceedings manuscript.**

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